

*REMARKS/ARGUMENTS**The Pending Claims*

Claims 198, 199, 203-207, 210-224 currently are pending. Claims 198, 199, 203-207, 210-215 and 218-224 currently are subject to examination. Claims 216 and 217 have been withdrawn in response to a restriction requirement.

Amendments to the Claims

The claims have been amended to point out more particularly and claim more distinctly the invention. In particular, claims 198 and 206 have been amended to recite that the concentration-gradient semiconductor quantum dot (claim 198), or each quantum dot of a series (claim 206), has a band gap energy that is non-linearly related to the molar ratio of the at least two semiconductors. Support for these amendments is found at, for example, paragraph 0054. Claim 212 has been amended to depend from claim 207 rather than cancelled claim 208, as supported by the specification at, for example, paragraph 0056. Claim 212 also has been amended to replace the term “are” with the more appropriate term “is.” No new matter has been added by way of these amendments.

Summary of the Office Action

Claim 212 has been objected to for being dependent upon a cancelled claim. Claims 198, 199, 203-207, 210-215 and 218-224 have been rejected under 35 U.S.C. § 103(a) as allegedly obvious over U.S. Patent 6,710,366 (Lee et al.) (“the Lee patent”) in view of U.S. Patent 6,207,392 (Weiss et al.) (“the Weiss patent”) alone, or further in view of U.S. Patent 6,846,565 (Korgel et al.) (“the Korgel patent”).

Reconsideration of these rejections is respectfully requested in view of the claim amendments and remarks herein.

Discussion of the Claim Objection

Claim 212 has been objected for depending on cancelled claim 208. Claim 212 has been amended to depend on claim 207, thereby rendering this objection moot.

Discussion of Rejection Under 35 U.S.C. § 103(a)

Claims 198, 199, 203-207, 210-215, 218, 220, 221, 223, and 224 have been rejected as allegedly obvious over the Lee patent in view of the Weiss patent, and claims 219 and 222 have been rejected as allegedly obvious over the Lee patent in view of the Weiss patent further in view of the Korgel patent. Applicants respectfully traverse this rejection for the reasons set forth below.

For subject matter defined by a claim to be considered obvious, the Office must demonstrate that the differences between the claimed subject matter and the prior art “are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.” 35 U.S.C. § 103(a); see also *Graham v. John Deere Co.*, 383 U.S. 1, 148 U.S.P.Q. 459 (1966). The ultimate determination of whether an invention is or is not obvious is based on certain factual inquiries including: (1) the scope and content of the prior art, (2) the level of ordinary skill in the prior art, (3) the differences between the claimed invention and the prior art, and (4) objective evidence of nonobviousness. *Graham*, 383 U.S. at 17-18, 148 U.S.P.Q. at 467.

1. *Scope and Content of the Prior Art*

The Lee patent discloses quantum dots comprising a core, a shell, and a region between the core and the shell referred to as an “interface region” (see column 7, lines 16-18). The Lee patent discloses that “the interface region may be homogenous or inhomogenous and may comprise chemical characteristics that are graded between the core and shell materials such that a gradual or continuous transition is made between the core and the shell” (see column 7, lines 25-29). The Lee patent discloses methods to produce shelled quantum dots as follows:

The fabrication of some types of shells on quantum dots can be performed using a variety of methods. Preferred methods include those described in X. Peng et al., “Epitaxial Growth of Highly Luminescent CdSe/CdS Core/Shell Nanocrystals with Photostability and Electronic Accessibility,” *J. Am. Chem. Soc.* 119, 7019 (1997) and B. O. Dabbousi et al., “(CdSe)ZnS Core-Shell Quantum Dots: Synthesis and Characterization of a Size Series of Highly Luminescent Nanocrystallites,” *J. Phys.*

Chem. B 101, 9463 (1997), the disclosures of which are hereby incorporated by reference in their entirety.

(column 33, lines 11-21).

The Weiss patent discloses that the emission wavelength of a semiconductor nanocrystal can be selected by varying the composition of the nanocrystal alloy (see column 8, line 61, through column 9, line 11). The Weiss patent discloses an illustrative embodiment, as follows:

[A] CdS semiconductor nanocrystal, having an emission wavelength of 400 nm, may be alloyed with a CdSe semiconductor nanocrystal, having an emission wavelength of 530 nm. When a nanocrystal is prepared using an alloy of CdS and CdSe, the wavelength of the emission from a plurality of identically sized nanocrystals *may be tuned continuously from 400 nm to 530 nm depending on the ratio of S to Se present in the nanocrystal.*

(column 8, line 64, through column 9, line 4) (emphasis added).

The Weiss patent discloses that methods to prepare nanocrystals in a core/shell configuration are described in Peng et al., *J. Am. Chem. Soc.*, 119 (30): 7019-7029 (1997) and Dabbousi et al., *J. Phys. Chem., B 101*: 9463-9475 (1997) (see column 8, lines 5-13 and column 29, lines 9-19), which are the same two references cited in the Lee patent as disclosing methods to produce shelled quantum dots.

The Korgel patent discloses semiconductor nanoparticles that can be used in light emitting diodes.

2. *Level of Ordinary Skill in the Art*

For the sake of argument and for purposes of the present analysis, one of ordinary skill in the art can be assumed to be someone with an advanced degree in chemistry, physics, or a similar science and/or several years of experience in the relevant art.

3. *Differences Between the Claimed Invention and the Prior Art*

Claims 199, 203-205, 207, 210-215, and 218-224 depend from claim 198 or claim 206, either directly or indirectly. As amended, claims 198 and 206 require, *inter alia*, a

concentration-gradient quantum dot (claim 198) or a series of concentration-gradient quantum dots (claim 206), wherein the quantum dot or each quantum dot in the series comprises an alloy of a first semiconductor and a second semiconductor, wherein the concentration of the first semiconductor gradually increases from the core of the quantum dot to the surface of the quantum dot and the concentration of the second semiconductor gradually decreases from the core of the quantum dot to the surface of the quantum dot, and wherein the concentration-gradient quantum dot has a band gap energy that is *non-linearly related to the molar ratio of the at least two semiconductors*.

The Office Action acknowledges that the Lee patent does not disclose specific ratios of semiconductor materials as claimed. The Lee patent also fails to provide any generalized method steps or any specific examples directed to a quantum dot comprising a gradual or continuous transition between the core and the shell. Furthermore, the Lee patent does not disclose any optical properties of a quantum dot comprising a gradual or continuous transition between the core and the shell.

The Weiss patent does not disclose a concentration-gradient quantum dot, much less a generalized method or specific example of preparing the same. As regards optical properties, the Weiss patent discloses that when a nanocrystal is prepared using an alloy of CdS, which has an emission wavelength of 400 nm, and CdSe, which has an emission wavelength of 530 nm, that the wavelength of the emission from a plurality of identically sized nanocrystals “may be tuned continuously from 400 nm to 530 nm depending on the ratio of S to Se present in the nanocrystal” (column 8, line 64, through column 9, line 4). The Weiss patent does not disclose a nanocrystal or quantum dot having a band gap energy that is non-linearly related to the molar ratio of the at least two semiconductors.

The Korgel patent does not disclose a concentration-gradient quantum dot, any generalized or specific method for preparing a concentration-gradient quantum dot, or any optical properties of a concentration-gradient quantum dot.

The Office Action alleges that because the Weiss patent discloses that tuning an alloy concentration would affect emission wavelength, routine optimization by one of ordinary skill in the art, in combination with the disclosure of the Lee patent, would have led to the invention of claims 198 and 206. However, Applicants respectfully submit that none of the

cited references discloses a concentration-gradient quantum dot or a series of concentration-gradient quantum dots having a band gap energy that is non-linearly related to the molar ratio of the at least two semiconductors as defined by the pending amended claims.

4. *Objective Evidence of Nonobviousness*

For purposes of the analysis here, there is no need to consider any objective criteria of nonobviousness.

5. *Consideration of Graham Factors Together*

As recently stated by the Supreme Court, “*there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.*” *KSR Int’l v. Teleflex Inc.*, 550 U.S. 398, 418, 82 U.S.P.Q.2d 1385, 1396 (2007) (quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) (emphasis added)). Here, the Office has failed to identify a credible reason why one of ordinary skill in the art would modify the teachings of the Lee, Weiss, and Korgel patents in such a way so as to provide a quantum dot or a series thereof, as recited in the pending claims.

In particular, as discussed above and in the previously submitted Rule 132 Declaration, the Lee patent fails to provide any generalized method steps or any specific examples directed to a quantum dot comprising a gradual or continuous transition between the core and the shell. As stated in the Rule 132 Declaration, there are no examples in the Lee patent directed to a quantum dot comprising a gradual or continuous transition between the core and the shell. The Lee patent also does not set forth any general methods of preparing a quantum dot comprising a gradual or continuous transition between the core and the shell, much less the specific methods that would be required to allow one of ordinary skill in the art to make such a quantum dot.

The Office states that the Rule 132 Declaration was not persuasive because “the focus of Applicants’ arguments are on the Lee patent alone teaching the concentration-gradient quantum dot” but the rejection is based on the combination of the Lee and Weiss references (Office Action, page 11, first full paragraph). Applicants’ acknowledge that the obviousness rejection of independent claims 198 and 206 is based on the combination of the Lee and Weiss patents, however, it is respectfully pointed out that the Office Action does not rely on

the disclosure of Weiss to provide a method of preparing a concentration-gradient quantum dot. Instead, the Weiss patent is relied upon for its disclosure that “the concentration of an alloy in a nanocrystal can affect the emission wavelength of the alloyed semiconductor nanocrystal” (Office Action, page 4, bottom paragraph). Thus, it should be deemed proper for the Rule 132 Declaration to solely comment on the lack of enabling disclosure of the Lee patent as regards a method of preparing a concentration-gradient quantum dot.

Nonetheless, Applicants note that the Weiss patent does not disclose a generalized method or a specific example of preparing a concentration-gradient quantum dot, as defined by the pending claims. Therefore, neither the Lee nor Weiss patents (nor the Korgel patent for that matter) provide *any* disclosure – enabling or otherwise – of how to prepare a concentration-gradient quantum dot. Without any teaching, pointer, or suggestion as to how to prepare the quantum dot comprising an “interface region,” as disclosed by the Lee patent, one of ordinary skill in the art would not have had a reasonable expectation of success to prepare a quantum dot encompassed by the pending claims.

The Office Action appears to contend that the claimed quantum dots are a product of merely altering the ratios of the particular metals used (Office Action, paragraph bridging pages 11 and 12). Such contention is not true because the presently claimed invention is based, at least in part, on Applicants’ surprising discovery that certain semiconductors (e.g., tellurium) are considerably more reactive than other semiconductors (e.g., selenium) towards a common semiconductor (e.g., cadmium) under rapid nucleation and growth conditions. This discovery was used to create a strategy for synthesizing two distinct types of quantum dots, specifically, quantum dots with a *gradient structure* produced under cadmium-rich conditions (see paragraph 00148), and quantum dots with a *homogenous structure* produced under cadmium-limited conditions (see paragraph 00152). It was also surprisingly discovered that an excess of one semiconductor (e.g., cadmium) relative to the total mole amounts of two other semiconductors (e.g., selenium and tellurium) led to the formation of alloyed dots with a gradient structure characterized by a band gap energy that is non-linearly related to the molar ratio of the at least two semiconductors (see paragraphs 0143 and 0152 and Figure 6). Moreover, Applicants found that the band gap energy can extend beyond the range defined by the band gap energies of the respective components.

Contrary to the Examiner's assertion that "Applicants' own specification does not provide much more guidance than what is described by Lee [and] [t]he most detail provided by the specification on how to make a concentration-gradient quantum dot is one paragraph (paragraph 143) ..." (Office Action, page 12, second paragraph), Applicants respectfully point out that the specification provides a detailed disclosure of a general method for producing a concentration-gradient quantum dot, or a series thereof (see, e.g., paragraphs 00107 and 00108). The general method includes a description of suitable temperatures, solvents, and metal precursors (see, e.g., paragraphs 00109-00113). Moreover, the specification provides ample disclosure of the unique optical properties of the concentration-gradient quantum dots of the invention as well as methods to characterize the unique optical properties (see, e.g., paragraphs 0054, 00146, 00147, and 00155 and Figure 8). A specific example of how to prepare a concentration-gradient quantum dot is described in detail in Example 5. Example 6 describes the characterization of the concentration-gradient quantum dots, whereas Example 7 describes a comparison study of alloyed semiconductor quantum dots, concentration-gradient quantum dots, and core-shell quantum dots. Therefore, the present application provides ample description of both generalized methods and specific examples of how to prepare a concentration-gradient quantum dot, which is in direct contrast to the lack of disclosure of the Lee patent.

An important aspect of Applicants' discovery is that the concentration-gradient quantum dots can be prepared in a *single step* by controlling the ratio of semiconductors, reaction temperature, growth time, and nucleation rate (see paragraph 00148), which method is distinct from the two-step methods known in the art at the time of the present invention to prepare core-shell nanocrystals (see paragraph 00149). As discussed above, none of the cited references provides any generalized methods or specific examples to prepare a quantum dot comprising a gradual or continuous transition between the core and the shell. In fact, both the Lee patent and the Weiss patent cite the same references (i.e., Peng et al., *J. Am. Chem. Soc.*, 119 (30): 7019-7029 (1997) and Dabbousi et al., *J. Phys. Chem., B* 101: 9463-9475 (1997)) as disclosing methods to prepare core-shell nanocrystals. However, as discussed in the present specification, Peng et al. and Dabbousi et al. both describe *two-step processes* which result in nanocrystals having an abrupt boundary between the core and the shell (see paragraph 00149).

Thus, the cited references fail to provide an enabling disclosure of how to prepare the claimed quantum dots. Therefore, one of ordinary skill in the art would not know how – nor have

a reasonable expectation of success – prepare any concentration-gradient quantum dot, much less a concentration-gradient quantum dot having a band gap energy that is non-linearly related to the molar ratio of the at least two semiconductors.

Furthermore, Applicants discovered a non-trivial synthesis method, previously unknown, to provide the claimed concentration-gradient quantum dot with the required optical properties. Such non-trivial synthesis includes quantum dots that are prepared in a single step by controlling, for example, the ratio of semiconductors, reaction temperature, growth time, and nucleation rate. These parameters are neither disclosed nor appreciated by any of the cited references, such that the ordinarily skilled artisan would not have had a credible reason to modify the disclosure of the Lee, Weiss, and/or Korgel patent in such a way as to arrive at the claimed quantum dot or a series thereof.

Even if, *arguendo*, one of ordinary skill in the art (i) stumbled upon some unidentified method to prepare a concentration-gradient quantum dot, and (ii) was led to combine the disclosure of the Lee, Weiss, and Korgel patents, he or she would be expected to arrive at – at best – a concentration-gradient quantum dot having an emission spectra somewhere *in between* the emission wavelength of the two semiconductor materials depending upon the mole ratio of semiconductors present in the alloyed dot. One would be expected to arrive at such dot (again, assuming one could prepare a concentration-gradient quantum dot in the first place) because the Weiss patent (i.e., the only cited reference which describes the optical properties of alloyed semiconductors) discloses that when a nanocrystal is prepared using an alloy of CdS, which has an emission wavelength of 400 nm, and CdSe, which has an emission wavelength of 530 nm, the wavelength of the emission from a plurality of identically sized nanocrystals “may be tuned continuously from 400 nm to 530 nm depending on the ratio of S to Se present in the nanocrystal” (column 8, line 64, through column 9, line 4). Based upon the teachings of the Weiss patent, one of ordinary skill in the art would *not* have developed a concentration-gradient quantum dot or a series of concentration-gradient quantum dots having a band gap energy that is *non-linearly related to the molar ratio of the at least two semiconductors*. The Weiss patent, in fact, teaches away from a concentration-gradient quantum dot having the claimed optical properties.

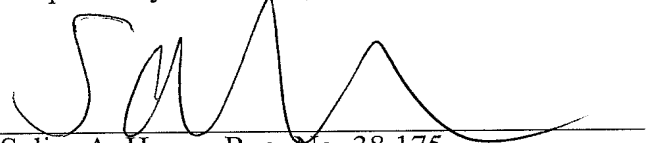
In view of the foregoing, the Office has failed to identify a credible reason why one of ordinary skill in the art would modify the optical properties of the alloyed semiconductor disclosed in the Weiss patent in the manner necessary (i.e., to achieve a band gap energy that is non-linearly related to the molar ratio of the at least two semiconductors), and then develop a concentration-gradient quantum dot having such modified optical properties based upon the disclosure of the Lee patent, in order to arrive at the present invention as defined by the amended pending claims.

Considering all of the Graham factors together and without a credible reason, it is clear that the present invention would not have been obvious to one of ordinary skill in the art at the relevant time in view of the cited references. Accordingly, the obviousness rejection of the pending claims should be withdrawn.

Conclusion

Applicants respectfully submit that the patent application is in condition for allowance. If, in the opinion of the Examiner, a telephone conference would expedite the prosecution of the subject application, the Examiner is invited to call the undersigned attorney.

Respectfully submitted,



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Date: February 26, 2010